Population Survey of Golden Eagles (*Aquila chrysaetos*) in the Western United States

A Proposal

Solicitation Number 982103R041

Prepared By:

Western **E**co**S**ystems **T**echnology, Inc.
2003 Central Avenue
Cheyenne, Wyoming 82001
Tel: 307-634-1756
Fax: 307-637-6981
http://www.west-inc.com

Prepared For:

Contracting and General Services - R9
U.S. Fish & Wildlife Service
4401 N. Fairfax Drive, Suite 212
Arlington, VA 22203

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1.0 Introduction and Project Understanding

To better manage golden eagle populations in the face of increasing demand for depredation permits by the agricultural community and for eagles by Native Americans for religious purposes, the U.S. Fish and Wildlife Service (USFWS) needs accurate population data for golden eagles across the western United States (US). During 2001, the U.S. Geological Survey (USGS) Snake River Field Station prepared an outline for monitoring golden eagle populations (Fuller et al. 2001). Based on recommendations by Fuller et al. (2001), the USFWS has issued a request for proposals (Solicitation number 982103R041) to design and conduct golden eagle population surveys in the western U.S.

GOAL

To goal of the project is to provide a thorough, objective, and scientifically rigorous population estimate of the golden eagle population in the study area comprised of Bird Conservation Regions (BCRs) 9, 10, 16, and 17 (North American Bird Conservation Initiative), within the boundary of the United States (Figure 1, reproduced from the USFWS Request for Proposal, Document 982103R041).

OBJECTIVE

Our overall objective in completing this project is to estimate the adult, subadult, and juvenile golden eagle populations sizes in the study area using aerial transect procedures such that, if replicated annually, would have at least 80% power to detect an annual rate of total population change greater than or equal to 3 percent per year over a 20-year period using a test of size alpha = 0.1 (or 90% confidence interval).

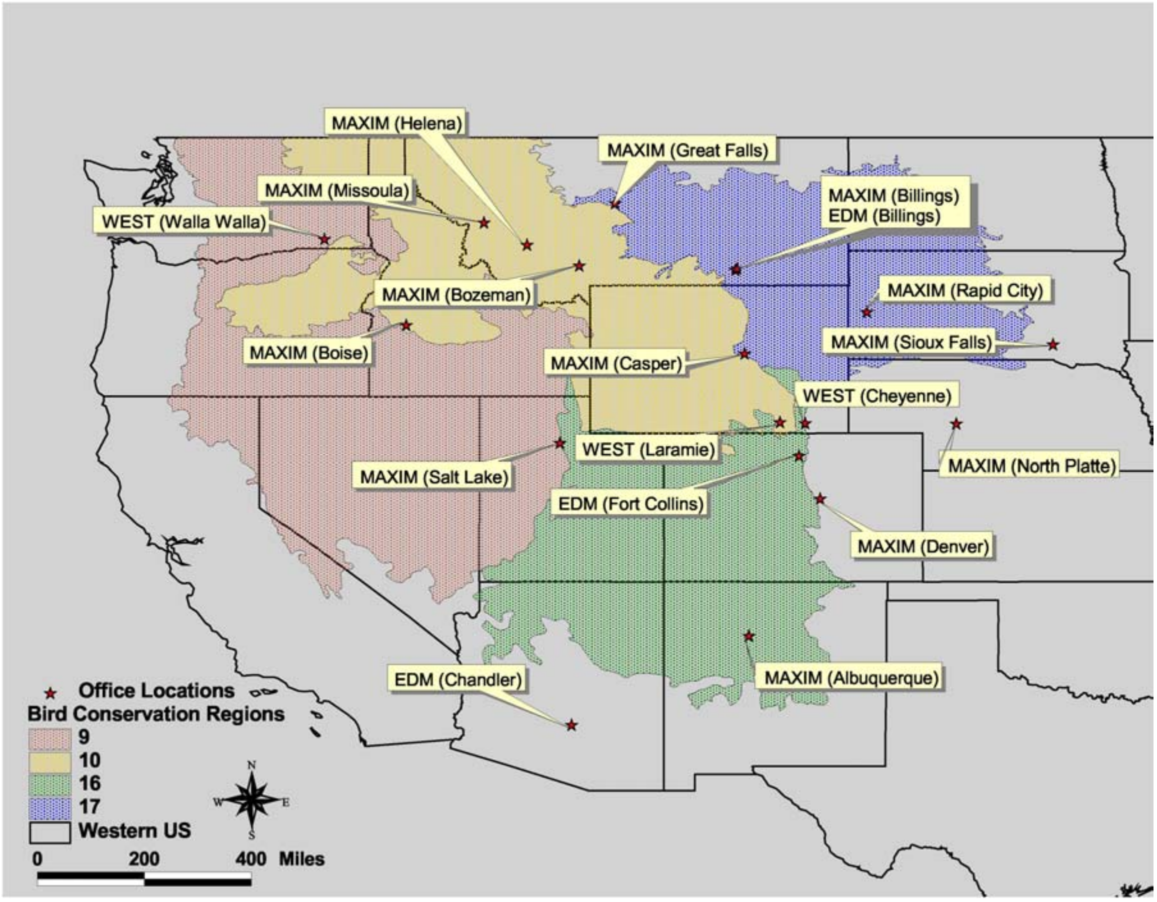

Figure 1. The approximate project area and our Team office locations.

2.0 The TEAM

Western **E**co**S**ystems **T**echnology, Inc. (WEST, Inc.) proposes a team approach to conducting the surveys. Team members have years of experience designing and conducting statistically rigorous population estimates for a variety of species using a variety of methods including aerial transects. Our personnel have extensive training and experience studying the ecology of raptor species in the western U.S. and conducting aerial surveys for golden eagles, along with a variety of other raptors.

WEST will serve as the prime contractor and has the primary responsibility for designing surveys, providing experienced field crew leaders, conducting eagle surveys, analyzing data, writing the final report and ensuring the project is completed. Other team members include Gerald (Jerry) Craig, Raptor biologist and private consultant, EDM International Inc., and Maxim Technologies, Inc. Jerry Craig's primary roles include applying his extensive knowledge of golden eagle biology to assist with survey design, training of field crews, assisting with interpretation of results and completion of the final report. The primary roles of EDM and Maxim include providing experienced crew leaders and members to conduct eagle surveys and providing general project support.

3.0 Corporate Qualifications

Prime Contractor. ***W**estern **E**co**S**ystems **T**echnology*, Inc., 2003 Central Avenue, Cheyenne, Wyoming 82001

WEST, Inc., offers clients a unique combination of field ecology and statistics to help solve natural resource problems. The corporation specializes in the use of state-of-the art statistical principles in the design, conduct and analysis of ecological studies including aerial surveys of golden eagles, sage grouse, moose, Dall's sheep, Pacific walrus, and polar bear. WEST, Inc. has a permanent core of 16 ecologists and biometricians with broad experience in basic and applied ecological studies and the sophisticated statistical analysis of natural resource data.

WEST, Inc. is headquartered in Cheyenne, Wyoming with field offices located in Laramie, Wyoming and Walla Walla, Washington.

Sub Contractor. *Gerald Craig, Raptor Biologist and Private Consultant*

As a wildlife researcher and state raptor biologist for the Colorado Division of Wildlife, Mr. Craig has 31 years of experience designing and conducting studies of raptor biology in the intermountain west. During his tenure with the Colorado Division of Wildlife, Mr. Craig provided expertise on raptorial birds statewide. His duties include administration the state's recovery programs for threatened and endangered species, dispensing expertise for the falconry program, conducting inventories and providing expertise to state and federal agencies on matters relating to raptors, their biology and habitat needs, and directing workshops on identification, biology, and management actions. Mr. Craig's primary responsibilities with the Colorado Division of Wildlife include developing and administering research projects to obtain knowledge of raptor biology, population sizes, habitat requirements, and publishing results in professional journals.

Sub Contractor. *EDM INTERNATIONAL, INC.*

Incorporated in 1982, EDM's Environmental Services Group offers a core team of experienced resource professionals that can provide progressive and credible approaches to often complex and controversial environmental issues. The Environmental Services Group of EDM specializes in a wide range of environmental issues and processes including avian research. Of particular importance to the proposed project, EDM has conducted numerous aerial surveys for nesting and winter raptors throughout the western U.S. for various projects, including golden and bald eagles. The personnel of EDM bring to the team years of experience designing and conducting aerial surveys for raptors, including bald and golden eagles.

Subcontractor. *Maxim Technologies, Inc.*

Maxim Technologies, Inc (Maxim), a wholly owned subsidiary of Tetra Tech, Inc., is an environmental consulting and engineering company with over 400 scientists, engineers, and support staff in 28 offices across the U.S. (Figure 1). The firm has provided environmental consulting and engineering services to a variety of governmental and commercial clients in the western U.S. since 1957. Maxim employs a core group of 15 biologists who are adept in conducting various types of wildlife and botanical surveys and in analyzing collected data to support a variety of applications. The wildlife biologists in the firm are supported by a very capable and experienced support cast, including environmental and engineering field technicians, GIS analysts, data base specialists, CAD operators, graphic artists, and statisticians. Maxim personnel have designed and conducted several aerial surveys for nesting raptors for various projects. Maxim has the manpower, strategically located field offices, and the biological and technological capabilities to support WEST, Inc. in making the proposed project a success.

In order to further illustrate the corporate qualifications of our team, we have provided a list and brief description of a few relevant projects involving aerial surveys and raptor biology our corporations have completed or are currently conducting:

Aerial Surveys of Large Raptors

Aerial Raptor Nest Surveys for Windpower Projects. Rhett Good and Clayton Derby, WEST Inc. have designed and conducted aerial surveys using helicopters for nesting golden eagles and other raptors at 16 separate wind plants in Oregon, Wyoming and Washington, logging over 500 flight hours from 1997 – 2003. Two surveys were conducted at most wind plants. Early spring surveys were conducted to identify species of nesting raptors and nest locations within 2 – 10 miles of proposed wind plants. A second survey was conducted at most wind plants to confirm breeding activity and measure nest productivity. Below is a list of representative projects where aerial surveys were conducted and client contact information:

- *SeaWest Foote Creek Rim Windplant, Carbon County, Wyoming.* SeaWest Energy Corporation, San Diego California. (619) 293-3340
- *Klondike Wind Project, Sherman County, Oregon*. Northwest Windpower Corporation, Goldendale, WA (509) 773-7303
- *Kittitas Valley Wind Project, Kittitas County, Washington.* Zilhka Renewable Energy. Portland, Oregon. (503) 222-9400
- *Zintel Nine Canyon Wind Project, Benton County, Washington.* Energy Northwest Resource Development. (509) 372-5087
- *Klickitat County Programmatic*, Goldendale, Washington (509) 773-7060

Aerial Raptor Nest Surveys for the BLM in Montana. Greg Leighty, Maxim Technologies, is currently involved in conducting eagle, falcon, and goshawk baseline studies for the Bureau of Land Management in the Rocky Mountain Front of west-central Montana to support analyses of potential environmental impacts from proposed oil and gas development on public and private land. This study involves utilizing fixed-wing aircraft to conduct aerial surveys to verify and validate nest occupancy and reproductive success of prairie falcons and golden eagles in the several square mile study area.

Bureau of Land Management - Rocky Mountain Front, West Central Montana, Teton County, Blackleaf Project –Bureau of Land Management, Lewistown, Montana (406)-538-7461

Raptor Surveys, Various Coal Mines, Montana. Mr. Bruce Waage, Maxim, conducted extensive aerial surveys for nesting raptors (including golden eagles) over wide expanses of proposed coal-development lands in southeastern Montana. Mr. Wagge utilized various survey methods to accomplish surveys, including making extensive use of global positioning systems. Mr. Waage logged over 550 hours of fixed-wing aircraft time conducting such surveys and gained significant experience in raptor identification, including type, age, and numbers during both breeding season and winter conditions.

Western Energy Company, Colstrip, Montana (406) 748-5186

Coal Bureau Department of Environmental Quality, Helena, Montana (406) 247-4433

TransColorado Gas Transmission Co., BLM, and USFS – Natural Gas Pipeline EIS, SEIS, and ROW Easement Reports for Escalante and Lone Cone SWAs – Colorado to New Mexico. Lori Nielsen, EDM, served as Project Coordinator and Wildlife Program Manager for an extensive 3-year biological field program encompassing aerial surveys for wintering and breeding bald eagles, other breeding raptor species, and Gunnison sage grouse and ground surveys for Mexican spotted owl, northern goshawk, burrowing owl, southwestern willow flycatcher, and kit fox for 300-mile natural gas pipeline between Meeker, Colorado and Bloomfield, New Mexico. The project included aerial surveys of the entire right-of-way were completed twice over this 3-year period to update associated raptor breeding data in accordance with the Bureau of Land Management's and U.S. Forest Service's programs.

*Bureau of Land Management***,** Jim Ferguson, Biological Manager, Montrose, Colorado. (970) 240-5300

Tri-State Generation and Transmission – Comanche to Walsenburg – Colorado. Lori Nielsen, EDM designed and conducted aerial raptor breeding surveys along 50-mile, 230-kV transmission line route between Pueblo and Walsenburg, Colorado. The survey focus was on nesting raptors occurring within 0.5 mile of the proposed transmission line right-of-way.

Tri-State Generation and Transmission, Denver, Colorado. (303) 452-6111.

U.S. Bureau of Reclamation – Navajo Reservoir RMP/EA – Colorado and New Mexico. Lori Nielsen, EDM designed and conducted aerial surveys for wintering bald eagles for Navajo Reservoir RMP/EA near Durango, Colorado and Farmington, New Mexico. Established winter roost sites were examined relative to proposed changes in terrestrial land use associated with Navajo Reservoir.

Bureau of Reclamation, Durango, Colorado. (970) 385-6500

Other Experience, Including Aerial Surveys of Other Species

Aerial Surveys for Moose. Ryan Nielson and Wallace Erickson, WEST, Inc., have designed, participated in, and analyzed aerial line transect surveys for moose (*Alces alces*) in Innoko National Wildlife Refuge, Alaska, since 1992. The surveys' methods involved counting moose in a stratified probability sample of moose study units using observers in a helicopter. The double-count observer method was used to adjust for the probability of detection through the use of statistical models including double sampling and logistic regression. The resulting densities contained estimates of precision and were extrapolated to the entire Refuge for the purpose of estimating moose abundance.

U.S. Fish and Wildlife Service, Innoko National Wildlife Refuge, Alaska

Supervised by Dr. Robert Skinner now with Charles M. Russell NWR, Lewistown, Montana (406) 538-8706)

Ryan Nielson and Wallace Erickson, WEST, Inc., have designed, and will participate in and analyze data from an aerial line transect survey for moose in the Alaska Peninsula/Becharof Refuges, Alaska. Data collection for this survey has yet to be completed, however WEST, Inc. has designed the survey and wrote the protocol for data collection and analysis. The work was planned for winter of 2003/04, but postponed because of a lack of snow cover.

U.S. Fish and Wildlife Service, Alaska Peninsula/Becharof Refuges, King Salmon, Alaska (907) 246-1214

Aerial Survey for Whooping Cranes. WEST has been assisting the Platte River Cooperative Agreement's Technical Committee in developing a protocol for aerial survey and monitoring whooping crane use and habitat utilization in the central Platte River valley, Nebraska, during spring and fall migration. This work has been part of a contract in which Dale Strickland has served as the Cooperative Agreement's Executive Director and other WEST personnel have served as technical staff for the Cooperative Agreement. The protocol has been implemented during four migration periods (spring and fall migration in 2001 and 2002). For three of these periods WEST served as contracting and technical coordination of the contract. This work included soliciting for contractors, evaluating contractors, assisting in selecting contractors, training, and daily oversight of the contractors. After the field survey portions WEST served as QAQC personnel for the data and database populated by the contractor. In the fall of 2001, the Technical Committee requested that WEST fully implement the protocol. Protocol implementation included daily aerial surveys from fixed wing airplanes, ground tracking of located cranes, field measurements at use sites, and estimates of observer detection bias using whooping crane decoys. After the field survey WEST prepared a draft report and worked closely with the Technical Committee in finalizing the report. During this survey period WEST developed the Access Database for all whooping crane data collected during protocol implementation. This database continues to be used and updated during subsequent implementation efforts. WEST also served as Peer Review Coordinator during the independent peer review of the Whooping Crane Monitoring Protocol.

U.S. Fish and Wildlife Service, Grand Island, Nebraska 308-382-6468

Aerial Survey for Polar Bear. Dr. Lyman L. McDonald, West, Inc., designed, participated in, and analyzed two aerial surveys for polar bears off the west and north coasts of Alaska between 1987 and 1994. Results of the surveys are given in the paper:

McDonald, L.L., G.W. Garner, and D.G. Robertson. 1999. Comparison of aerial survey procedures for estimating polar bear density: Results of pilot studies in Northern Alaska. In Garner, G.W., S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, eds. *Marine Mammal Survey and Assessment Methods.* A.A. Balkema, Rotterdam, pp. 37-51.

The second aerial survey used a double observer design as proposed for the current work. Statistical analysis of the data is described in the paper:

Manly, B.F.J., L.L. McDonald, and G.W. Garner. 1996 Maximum likelihood estimation for the double-count method with independent observers. *Journal of agricultural, Biological, and Environmental Statistics* 1:170-189.

U.S. Geological Survey, Alaska Science Center, Anchorage, Alaska (907)786-3424

Aerial Survey for Dall's Sheep. WEST designed and conducted an aerial survey for Dall's sheep in the Wrangle-St. Elias Park and Preserve (WSEP). The study was conducted from 1990 through 1992. Study objectives were to develop a safer and more reliable estimate of Dall's sheep in comparison to historical survey methods. The survey method included a relatively intensive survey of a probability sample of Dall's sheep study units using a helicopter, followed by a less intensive survey of these and other units using a fixed-wing aircraft. The observations from the fixed-wing, less intensive survey were adjusted for the probability of detection through the use of statistical models including double sampling and logistic regression. The resulting densities contained estimates of precision and were extrapolated to the entire WSEP for the purpose of estimating Dall's sheep abundance.

National Park Service, Anchorage, Alaska

Supervising Scientist was Dr. Kurt Jenkins now with USGS Biological Resources Division (360) 565-3041

Aerial Surveys for Mule Deer. Hall Sawyer, West, Inc., has designed, conducted, and analyzed aerial quadrat surveys for mule deer in the Green River Basin of Wyoming. Surveys were designed to estimate mule deer density and abundance (2001-present). Survey methods involved a systematic sample of 1-mi^2 study units using a helicopter. Potential visibility bias associated with group size, habitat, and weather conditions was addressed in study protocols. Approximately 50% of the 150-mi^2 study area was sampled. Density and abundance estimates were extrapolated to the entire study.

Bureau of Land Management, Questar-Wexpro Company, and Wyoming Game and Fish Department, Pinedale, Wyoming (307) 367-4353

Review of Mountain Goat Aerial Survey Procedures, Olympic National Park, Washington. Dr. Lyman L. McDonald, West, Inc., reviewed the aerial survey procedures for estimation of abundance of mountain goats in Olympic National Park under contract to the USGS. Dr. McDonald participated in a workshop with other statisticians and biologists to discuss and arrive at consensus for aerial survey procedures. A final report based on the workshop and reviews by the participants has been prepared by Dr. Kurt Jenkins, USGS.

USGS Biological Resources Division, Port Angeles, WA (360) 565-3041

Raptor Population Modeling. Wally Erickson, WEST, Inc. modeled trends in reproductive parameters of golden eagles, prairie falcons and ferruginous hawks in relation to the mining operations at the Black Butte Mine in Wyoming. Randomization tests of trend were conducted on occupancy, nest success, and fledging rates for assessing impacts of the mine on the local raptor populations. Results were summarized in a technical report.

Kiewit Mining Group, Omaha, Nebraska.

Review of Golden Eagle Population Model. Wally Erickson and Bryan Manly of WEST provided a peer review of the field and statistical methods, results and conclusions of a report entitled "Golden Eagles in a Perilous Landscape: Predicting the Effects of Mitigation for Energy-Related Mortality". This report focused on modeling the population status of golden eagles in the vicinity of the Altamont WRA. WEST was asked, due to their experience in population level modeling, to focus on the assumptions and statistical methods used to model 8, the population rate of change.

California Energy Commission, Sacramento, California. (916) 654-4287

Long Term Ecological Monitoring Program for Denali, Yukon Charlie Rivers and Wrangell-St. Elias National Parks, Alaska. Dr. Lyman L. McDonald, Dr. Trent L. McDonald, and Mr. Ryan Nielson, West, Inc., have worked under contract from 1999 to the present with the Alaska Science Center of the USGS, Anchorage Office, to provide review and development of the Long Term Ecological Monitoring Program for the Alaska Network of Parks. The initial contract was for review of the ongoing ecological monitoring program in Denali National Park. West, Inc. personnel have participated with National Park personnel in Alaska in workshops and conferences on ecological monitoring. Latter projects include computer simulation of properties of candidate sampling and analysis plans based on pilot data.

U.S. Geological Survey, Alaska Science Center*,* Anchorage, Alaska (907) 786-3579

4.0 Key Personnel and Management Approach

The personnel of our team have extensive experience designing and conducting statistically rigorous population estimates for a variety of species using aerial transects. The following material describes project personnel, their training and experience, and our proposed management approach. We have also provided details of our professional experience designing, conducting, and analyzing aerial transect surveys. The Team's organization is illustrated in Figure 2.

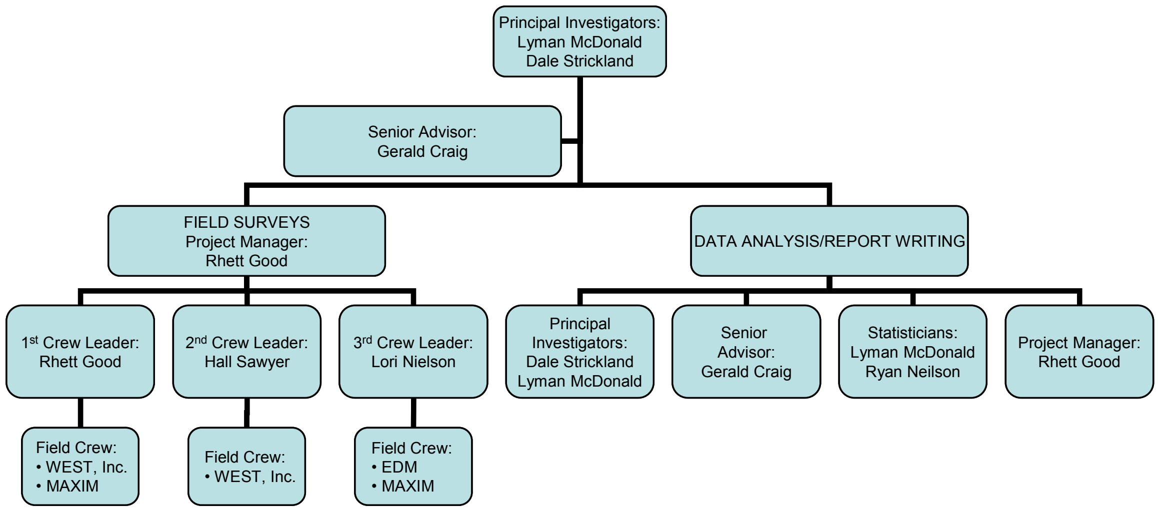

Figure 2. A flow chart illustrating our Team organization.

Personnel Experience

Principal Investigator.
Dr. Lyman L. McDonald, WEST, Inc.

Dr. McDonald is President and Senior Biometrician with WEST, Inc. He is a statistician with more than thirty years of comprehensive experience in the application of statistical methods to design, conduct, and analyze environmental and laboratory studies. His specialties include survey of wildlife populations, sampling of biological communities, calibration of biased sampling procedures, jackknifing and bootstrapping procedures, capture-recapture and tag-recovery statistics, general linear models, and multivariate analysis.

Dr. McDonald has designed, participated in and analyzed both large and small wildlife and environmental monitoring programs, including aerial surveys for waterfowl, polar bear, Pacific walrus, and Dall's sheep. He has experience in terrestrial and aquatic ecosystems including marine environments. His experience has lead to appointments to regional and national technical advisory and review committees, including the Independent Scientific Advisory Board (ISAB) to the Northwest Power Planning Council and the National Marine Fisheries Service concerning scientific and technical issues related to their fish and wildlife programs and the Statistical Design and Analysis Team for the U.S. Environmental Projection Agency Environmental Monitoring and Assessment Program (EMAP). Dr. McDonald is the author of more than 75 papers in the scientific literature and is joint author on the 2002 Second Edition of the book entitled Resource Selection by Animals: Statistical Design and Analysis for Field Studies. He has also organized and taught workshops on statistical procedures for practicing biologists.

Dr. McDonald has the training and experience to conceive practical, common sense solutions to environmental sampling-monitoring problems that are consistent with feasible field and laboratory methods and give rise to defensible statistical inferences.

Co-Principal Investigator.
Dr. M. Dale Strickland, West, Inc.

Dale Strickland is Vice-President and Senior Ecologist with Western EcoSystems Technology, Inc. (WEST) in Cheyenne, Wyoming. He received a B.S. in Zoology (1969) and an M.S. in Wildlife Management (1972) from the University of Tennessee and a Ph.D in Zoology from the University of Wyoming (1975). Prior to his employment with WEST he served as a scientist and administrator with the Wyoming Game and Fish Department and served on the faculty of the Department of Statistics at the University of Wyoming. He has also taught courses in wildlife management and statistics as a visiting instructor at the University of Wyoming.

He has over thirty years of experience in ecological research and wildlife management. Specialties include the design, conduct, and analysis of field studies of terrestrial and avian wildlife, threatened and endangered species, and impact, risk, and injury assessment studies. He is author of more than 75 papers and technical reports in the scientific and popular literature on wildlife research and natural resource conservation and management. He is the lead author of a chapter on harvest management in the 5th edition of the Wildlife Techniques Manual and co-author of the text "Wildlife Study Design" published in 2001. He contributed to documents for the National Oceanic and Atmospheric Administration for the quantification of injury due to oil spills in Type B Natural Resource Damage Assessments and authored a chapter in a guidance document on the conduct of research on avian wind power interactions for the National Wind Coordinating Committee. Dr. Strickland is currently serving as the Executive Director of the Platte River Endangered Species Partnership. He and his staff provide technical and administrative support for the Governance Committee, which oversees the development of The Platte River Recovery Implementation Program (Program). He is a member of the American Statistical Association, The Ecological Society of America, Certified Senior Ecologist, The Wildlife Society, Certified Wildlife Biologist, and The Wyoming Chapter of The Wildlife Society, Past President.

Senior Advisor.
Mr. Gerald R. Craig, Raptor Biologist and Private Consultant

Of particular importance to the proposed project, Mr. Craig has extensive knowledge and experience with the ecology of golden and bald eagles. For his Master's research Mr. Craig studied the nesting habits of golden eagles in the state of Colorado. As part of his duties with the Colorado Division of Wildlife as the state's Raptor Biologist, he has developed and implemented aerial transects to inventory wintering eagles in northeastern and northwestern Colorado as well as the San Luis Valley, and developed and implemented statewide golden and bald eagle nest inventories. These inventories include annually banding and color marking nestling bald eagles throughout the state. Mr. Craig coordinates and compiles annual statewide midwinter bald eagle inventories that include fixed-wing flights of major drainages and ground counts of concentration areas. Mr. Craig also annually monitors peregrine falcon nest occupancy and productivity throughout Colorado.

Mr. Gerald Craig's extensive knowledge of golden eagle ecology and expertise in designing and conducting population surveys will allow statistically rigorous methods to be utilized in a manner that allows for biologically significant interpretation of survey results.

Project Manager and Field Supervisor.
Mr. Rhett Good, West, Inc.

Rhett Good has been a Field Supervisor and Wildlife Biologist for WEST, Inc. since 1998. He received his B.S. in Biology from Ball State University (1995) and an M.S. in Zoology and Physiology from the University of Wyoming (1998). Rhett has a wide range of experience conducting logistically complex field studies for several species and habitat types. He has studied the foraging ecology of northern goshawks for his Master's research, the breeding ecology and distribution of mountain plovers in Wyoming, the effects of wind power on golden eagles, songbirds, big game and T&E species at several locations in Washington, West Virginia, Oregon, Nebraska, South Dakota, Oklahoma and Wyoming, the impacts of highway construction, cellular towers, oil and gas development and various other construction projects on a variety of wildlife throughout the U.S.

Mr. Good's area of expertise includes raptor biology and ecology. Mr. Good's experience with raptors includes a study of goshawk hunting habits in south-central Wyoming for his Master's degree, design and conduct of raptor use and impact studies at several wind plants in Wyoming, Oregon and Washington, conduct of ground based raptor nest surveys for several Wyoming Department of Transportation Projects and cellular towers. Mr. Good has 8 years of experience identifying and aging golden eagles. During raptor use surveys at several wind plants, Mr. Good was required to age and identify golden eagles and other raptor at long distances (0.5 – 2 miles). Mr. Good has also conducted aerial surveys for nesting golden eagles and other raptors at 15 separate wind plant in Oregon and Washington, logging over 300 flight hours from 2001 – 2003. Mr. Good has the training and experience to design and conduct logistically complex field studies.

Project Biometrician.
Mr. Ryan Nielson, West, Inc.

Ryan Nielson is a biometrician/statistician with experience designing, participating in, and analyzing data from aerial line transect surveys. This experience includes moose surveys in the interior of Alaska, moose surveys on the Alaska Peninsula, and gray whale surveys off the northeastern coast of Russia. Mr. Nielson has also designed, participated in, and analyzed data from other wildlife and environmental monitoring programs including long term monitoring plans for resources in Denali National Park and Preserve, Alaska, coho abundance in northern California, and spotted owls in the Pacific Northwest.

Mr. Nielson has experience in simulation and computing using SAS, S-Plus and Matlab. Working in cooperation with field researchers, resource managers and the public has provided Ryan with skills to solve problems associated with study design and analysis, and project management.

Field Supervisor
Mr. Hall Sawyer, WEST, Inc.

Mr. Sawyer is experienced with both ground and aerial raptor surveys, and is familiar with distribution, life-history, identification and aging of raptors that occur in the Intermountain West. His raptor related aerial work includes fixed-wing bald eagle nest surveys conducted across a large region of northwest Colorado, including the Yampa and White Rivers. Eagle surveys were conducted annually and intended to determine activity of existing nests and search for new nests.

Mr. Sawyer has years of experience designing and conducting scientifically rigorous surveys for wildlife using aerial survey methods. Mr. Sawyer has accumulated >650 hours of fixed-wing and helicopter flight time conducting wildlife surveys across the Intermountain West. Mr. Sawyer also has experience with a variety of survey methods including, line transect counts, quadrat counts, random searches, and stratified searches. His aerial work has included raptor surveys, big game counts, big game (mule deer, pronghorn, elk, and bighorn sheep) composition surveys, grizzly bear moth flights, and assorted telemetry flights and he is adept with state-of-the-art GPS navigation and data collection. Mr. Sawyer's familiarity with logistics of coordinating and conducting large-scale aerial surveys, including aircraft configurations, safety requirements, flight-following procedures, weather/altitude considerations, and flight restrictions makes him uniquely qualified to serve as a field supervisor for this project.

Field Supervisor
Ms. Lori Nielsen, EDM International, Inc.

Ms. Nielsen is a senior wildlife biologist and biological program manager with over 17 years experience conducting environmental analyses and resource planning primarily throughout the western U.S. She specializes in problem resolution for wildlife issues in accordance with the Endangered Species Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act. The focus of her field and impact studies typically encompasses high-profile raptor species, such as the bald eagle, golden eagle, ferruginous hawk, peregrine falcon, prairie falcon, Mexican spotted owl, and osprey, examining the short- and long-term effects to these species from a variety of human-related activities. In support of these studies, Ms. Nielsen has completed over 3,500 miles of helicopter and fixed-wing surveys for breeding and wintering raptors, waterfowl, and both the greater and Gunnison sage-grouse. Presently, Ms. Nielsen is managing an unprecedented statewide study in Colorado of electrocution risk to raptor species for 22 participating utilities, with an emphasis on effects to both bald and golden eagles. She also is currently working with the U.S. Fish and Wildlife Service on similar ground survey programs on six National Wildlife Refuges in the western U.S.

Field Supervisor
Mr. Bruce Waage, Maxim Technologies, Inc.

Mr. Bruce Waage, with Maxim's Billings, Montana office, is a senior biologist with over 25 years of experience, serving as a coal industry biologist and as a consultant to a variety of clients. His experience has ranged from his role as principal investigator in conjunction with raptor and grouse studies to completing research of wetland performance in association with mine reclamation. Mr. Waage has conducted extensive aerial surveys of raptors (including golden eagles) over wide expanses of proposed coal-development lands in southeastern Montana. He has utilized various survey methods to accomplish surveys, including making extensive use of global positioning systems. He has logged over 550 hours of fixed-wing aircraft time conducting such surveys. Mr. Waage has also lead efforts to complete sharp-tailed grouse surveys of the Dakota Prairie National Grassland, identifying likely habitats and inventorying elk locations and general population characteristics. Also, Mr. Waage has served as principal investigator in conducting an extensive effort to trap and instrument grouse in conjunction with baseline investigations at a large-scale coal mine in southeastern Montana. This effort also included use of telemetry to track the occurrence, distribution, and movement characteristics of these birds. Mr. Wagge has the experience and expertise to serve as field supervisor for this project.

Other Personnel

WEST, Inc., Maxim Technologies and EDM employ several wildlife biologists available to conduct the proposed field work. Our biologists have experience designing and conducting various ecological field studies, including the use of aerial transects. Their resumes and project experience are attached.

5.0 Proposed Project Approach

We propose to use aerial transect surveys in late summer-early fall as the primary source of data for the estimation of populations sizes of juvenile (young of the year), immature (1 to 4 years old through the late summer of their 4^{th} year), and adult golden eagles (about 4.5 years and older). Our survey methods and proposed sample sizes are based largely on Fuller et al. (2001) with important modifications.

Our proposal differs from the recommendations in Fuller et al. (2001) in one fundamental and critical area. Fuller recognized that for estimates of population sizes from aerial transect surveys to be unbiased, the probability of detection must be known or estimated. The Fuller et al. report suggests, "attaching radio transmitters to a sample of birds [golden eagles] and then conduct a separate series of flights to estimate the probability of detecting these birds," (Fuller et al. 2001, pg 18). This evaluation of detection could then result in "correction" factors for data from the actual surveys to obtain unbiased estimates of population sizes. We propose to incorporate the evaluation of detection probabilities into the operational surveys using "double-observers" on approximately one-third of the survey flights. The double-observer method has been extensively evaluated by statisticians and biologists in the scientific community and is a widely accepted method (Manly et al. 1996, McDonald et al. 1999, Seber 1982, Pollock and Kendall 1987). The double-observer procedure will allow us to develop correction factors for the number of eagles missed on each flight, and will allow us to determine if the age of the eagle influences detectability of the bird. Fuller et al. recognized that incorporating the evaluation of detection of golden eagles into the operational surveys was "ideal" (Fuller et al. 2001, pg18). A brief discussion of double-observer methodology is given below, and in the Statistical Methods section.

Primary advantages of the double-observer approach are that surveys can be conducted immediately without waiting for a long, expensive study that involves handling a significant number of golden eagles. With the double-observer method correction factors will be developed for unique combinations of aircraft, habitat type, and terrain. We note that standard "line-transect or distance sampling" procedures are not appropriate for the survey, because the probability of sighting an individual on the transect line is not guaranteed to be 100%. However, the "double-observer" method for correction of visibility bias does not depend on this assumption. The statistical analysis behind the double-observer method involves using logistic regression models to estimate the probability that an individual at a given distance (including birds close to the transect line) will be sighted.

Based on the best available information provided by Fuller et al. (2001), we propose to conduct the aerial survey with a goal of detection of 200 eagles in the study area, as recommended by Fuller et al. At their projection of 1.2 eagles per 100 km of flight line, we propose to fly 16,500 km of transect in the entire study area. Estimates of numbers of eagles in the study area will be obtained, with the objective of detecting a yearly 3% population change over 20 years of surveys with a beta level of 0.80.

Two different methods exist for analyses of aerial transect distance data: model based and design based. Classical analyses of line-transect and distance data were conducted by model based methods requiring the assumption that individual eagles (or groups) are randomly distributed in the survey area, i.e., the observed individuals are a random sample from the population, and that individual eagles or groups of eagles are considered to be the experimental unit with the number observed as the "sample size." The effect of violating this assumption is that model based confidence intervals tend to be biased in unknown directions, i.e., the standard errors are either too large or too small and the intervals are too wide or too narrow. Thus it is impossible to determine the range of variability (i.e. precision) of population estimates by using individual eagles as sampling units as attempted by Fuller et al. (2001). The solution to this problem is to use design based methods where the experimental units are considered to be the transect lines and the "sample size" is the number of transect lines flown, not the number of eagles detected (Borchers et al. 2002, Buckland et al. 2001). We propose to use computer intensive procedures to resample the transect lines (e.g., nonparametric bootstrap) to estimate the standard errors of the population abundance. Using these procedures, violation of the assumption of random distribution of eagles is of no great consequence (Manly 1997, Borchers et al. 2002). We will report estimates of standard errors by both methods and evaluate the need for design based analysis and use of the more computer intensive methodology in design and analysis of future surveys.

The need for computer intensive design based analysis is discussed above because it points out an inconsistency in the background material recommended by the USFWS. Namely, the standard errors generated by Fuller et al. (2001) are based on the classical model based assumptions for distance sampling (using individual eagle observations as experimental units) and hence the recommendations of Fuller et al. concerning the number of birds to be detected and length of transect lines to be flown depend on untested assumptions. The survey and analytic methods we propose use the individual transects as experimental units, and will allow unbiased estimation of golden eagle population sizes in the study area, a correct variance estimate, and following the first year of surveys, a more accurate estimate of the number and length of transect lines needed to obtain the desired level of precision, i.e. the ability to detect a yearly 3% population change over 20 years of surveys with a beta level of 0.80.

Although golden eagles occur more frequently within open shrub and grassland habitats, golden eagles will also nest at lower densities within other habitats, such as coniferous forests. Additionally, golden eagles will use openings within forests to hunt (Kochert et al. 2002). Because golden eagles may occur in virtually every habitat type in North America, we will survey all habitats with the following exceptions: open water, ice / snow, areas above 5,000 m, large metropolitan areas (e.g. urban areas of Salt Lake City, Las Vegas) and areas with restricted airspace, such as military bases and sensitive areas within National Parks.

We recommend against stratification of the study area in the initial survey based on expected eagle densities, because appropriate data for stratification do not exist. One exception is the Snake River Birds of Prey Area that will be sampled separately (see below). As indicated above, the precision of the population estimate does not depend on the density of golden eagles in a sub-region, and thus stratification will not guarantee higher precision. Variation among transects may be lower in areas with low density of golden eagles than it is in areas with high density, or the reverse may occur. The best strategy for design of a long term monitoring program for golden eagles is to develop a standardized survey procedure that is repeatable with corrections for major visibility biases using a uniform distribution of relatively short transects over the study area. As recommended by Fuller et al. (2001), analysis of results of the survey during the first year would then be used to refine the survey design including stratification of future survey effort to optimize time spent conducting surveys.

Finally, we note that visibility correction factors will be developed for birds that are “available” to be sighted, but for whatever reason, are not detected by an observer. As in all line-transect (distance) type surveys, there are no corrections for individuals that are truly hidden from view. For example, in rough terrain some individuals may be out of sight (Thompson et al. 1998). For this reason, estimates of the population size will be conservative, however if the procedures are repeated over time then the power to detect an annual rate of population change should not be affected.

Information Collection

Based on the recommendations of Fuller et al. (2001), we propose to survey 165 transects 100 km in length, for a total of 16,500 km of transects in the entire study area. Fuller et al. (2001) recommend this length of transect to obtain a total of 200 observations in order to meet USFWS precision requirements under the model based assumptions discussed above. This recommendation represents the best information available for planning the current survey.

Transects will be distributed in a uniform, systematic manner throughout the entire study area. Sampling of transects to be flown in the survey will involve creating a uniform grid of transects and randomly placing the grid over the study area. This is equivalent to a systematic sample of transect locations with a random start (Cochran 1977) and will allow inference of population estimates to each individual Bird Conservation Region in the study area, as well as inference to the entire study area itself. A systematic sample is spread evenly over the study area, which is expected to make the systematic sample considerably more precise than a random sample (Cochran 1977). Figure 3 illustrates the potential distribution of transects within Bird Conservation Region 17. Essentially, within a Bird Conservation Region, transects will be distributed based on the proportion the BCR occupies within the entire study area (Table 1).

Table 3. The number of transect that will be located within each BCR.

BIRD CONSERVATION REGIONS	PROPORTION OF STUDY AREA	APPROXIMATE NUMBER OF TRANSECTS
9	0.29	48
10	0.37	61
16	0.20	33
17	0.14	23
Total	*1.0*	*165*

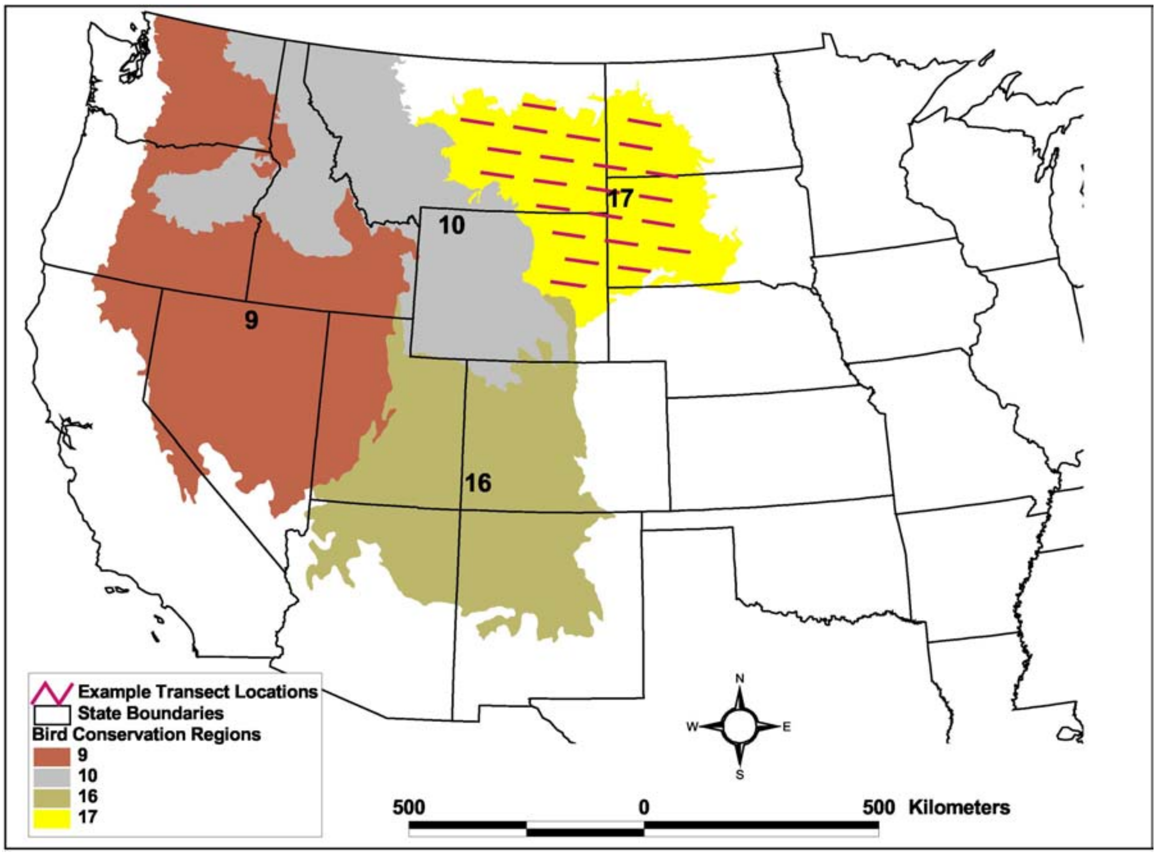

Figure 3. A map of the study area and an example of transect locations within BCR 17.

Methodology for flying aerial transects. We propose two slightly different methods for conducting aerial surveys, based on safety and flying conditions: 1) Surveys within relatively flat and open terrain (safer flying) and 2) Surveys within relatively rugged terrain (steep topography, coniferous forest, steep canyons) that involve less safe flying conditions.

Within areas providing relatively safe flying conditions (i.e. open terrain), surveys will be conducted according to recommendations by Fuller et al. (2001). Surveys will be flown at an approximate air speed of 145 kmph and the airplane will be maintained at an altitude of 61 m above the ground level (AGL).

Within areas providing less safe flying conditions (i.e. mountainous terrain), the airplane will be maintained at an approximate altitude of 100 m AGL and flown at approximately 145 kmph. Flying at higher AGL in rough terrain will allow pilots more flexibility in handling dangerous flying conditions. We expect the detectability of birds to decrease as the height of the airplane increases, however, the statistical methods proposed will account for this change in detection. This will be accomplished by estimating separate correction factors for transects flown over open terrain versus transects flown over mountainous terrain.

Number of flight hours. We estimate that 244 total flight hours will be required to complete the surveys, including travel between transects (Table 2).

Table 4. A summary of flight hours required to complete the project.

Activity	Flight Hours	Notes
Transect	114	16500 km flying at 145 kmph
Age Bird and GPS	36	10 minutes / bird assuming 200 birds
Ferry Time between Transects	78	The plane can be flown at higher speeds between transects
Training	16	One day for aging and ID training and one day for methods training
Total	***244***	

Number of flight crews. We propose to use three crews to complete the required surveys (total of 228 hours). Each crew will complete approximately 73 hours of transect flight and ferry time between transects. We have a 27 day window for completing surveys (August 18 – September 15), thus an average of 2.8 flight hours per day per crew is required to complete the surveys. We believe an average of 4 hours per day is a reasonable estimate for the amount of flying a crew can accomplish in a day considering bad weather, fatigue, and traveling between airports. Averaging 4 hours per day, three crews can finish the required surveys in approximately 19 - 27 days. Survey efforts will be distributed evenly between the three crews.

Timing of surveys. Based on information presented in Fuller et al. (2001) and Kochert et al. (2002), we propose to start surveys August 18, 2003 and finish surveys by September 15, 2003. Although median passage dates for golden eagles at most migration count sites for golden eagles occur around the 1st of October, counts of golden eagles reach 10 per day or higher at most sites around September 15, with counts of 1 – 5 eagles per day beginning in late August. The average fledging dates for golden eagles is June 15, with juveniles moving from 5 – 10 km from nests up to 3 months after fledging (Fuller et al. 2001). Thus, during our proposed survey period most immature golden eagles will be 5 + km from nest sites, and only very small number of eagles will have begun migration, providing a survey period which occurs after most eagles have fledged but before most eagles have begun migration.

Based on recommendations by Fuller et al. (2001) surveys will not be conducted from north – south because median passage dates for eagles does not appear to be related to latitude. Rather, transects will be surveyed so that they may be finished in the most efficient manner possible.

Depending on weather conditions, surveys will be conducted throughout the day. During the early morning hours, all transects will be flown in a east to west orientation in order to provide the best possible light for detecting eagles. During the late morning and afternoon, transects will be flown either direction. Transects conducted during the late evening will be flown in a west to east orientation.

During the late summer, golden eagles may spend more time flying in the afternoon when the air temperature warms and thermals are available. Because detection probabilities of flying versus perched eagles may differ, the detection probabilities may vary with time of day. Using modeling procedures, we will determine if detection probabilities vary with time of day or perched vs flying eagles, and adjust our population estimates accordingly.

Observers/aircraft. There will be two main observers in each aircraft. A third observer will rotate among the three survey crews and this observer will take the role of the "double-observer" in order to estimate detection rates for each survey crew, with the goal of obtaining approximately 100 eagle detections for correction estimates. In general, we will assign the "double-observer" to transects which are believed to have relatively higher probability of detection of golden eagles in order to maximize the number of sightings that can be used in logistic regression analysis for development of the "detection probability model." The number of eagles observed during double observer periods will be monitored throughout the surveys. Service personnel will be invited to accompany surveys on transects that do not require participation by the team's "double-observer."

The Snake River Birds of Prey Area will be sampled separately from the rest of BCR 9. We propose this modification of the systematic sample of transects for two reasons. First, we will use a "double-observer" in the area to potentially increase the number of eagles detected for development of the visibility correction model. Second, the method will insure that we do not miss an area known to have high density. The estimated number of golden eagles in the Snake River Birds of Prey Area will be added to the estimate for the rest of the study area.

DISTANCE sampling (Buckland et al. 2001) requires 100% detection of animals on the transect line, i.e., on the inside edge of the survey strip visible to the observer. When this assumption is violated, the DISTANCE procedures estimate only relative abundance and not population size (Borchers et al. 2002). For this reason, a modified line transect survey will be conducted. In this modification, a double-count sampling approach (Borchers et al. 2002; McDonald et al. 1999; Manly et al. 1996) will be conducted on the right side of the aircraft, using the recorder (front-right seat) to estimate detection probabilities of the back right observer (see statistical methods). Logistic regression (Hosmer and Lemeshow 2000) will be used to build a model for estimation of the proportion of birds detected by the front seat observer, but missed by the rear seat observer (in the same field of view). The model may include age class of the golden eagle and habitat type (eg. rough versus open terrain) or other covariates. This method differs from DISTANCE sampling in that the assumption of 100% detection on or near the transect line is not necessary, and we can actually estimate detection of birds at any distance from the aircraft in multiple types of landscapes. In the future, the double-observer method may not be needed, if probability of missing ground birds on the line, or birds close to the aircraft is small. This would result in less expensive, more efficient surveys for the following years when only two observers will be needed in each aircraft.

Training. We propose a three day training session for all crew members. The purposes of the training are threefold 1) Improving and standardizing crew members abilities to identify and age golden eagles from the air, 2) standardizing survey methodology and 3) providing each crew member with safety training required by the Department of Interior. The first day will be composed of a workshop taught by Bill Clark focusing on aging criteria for golden eagles from fixed wing aircraft. Mr. Clark is a world renowned raptor expert and founding Director of the Cape May Bird Observatory. Mr. Clark is the author of A Photographic Guide to North American Raptors and Peterson's Field Guide to Hawks. Mr. Clark has also published a paper on aging criteria for golden eagles (Bloom and Clark 2001). The workshop will focus on identifying and aging golden eagles from a fixed wing plane. The workshop include a 1 – 2 hour slide show in which Bill Clark will describe key criteria for aging eagles to juvenile, subadult and adult age classes. After the slide show each crew member will spend 1 – 2 hours with Bill Clark in the airplane practicing aging golden eagles from the air. Training will take place in Laramie, Wyoming. Golden eagles are readily observed within 1 – 10 miles of the Laramie Regional Airport.

During the second day crew members will be trained on methodologies and Standard Operating Procedures. Jerry Craig will use his 31 years of raptor experience to help train our crew members. Each crew member will participate in a 2 – 4 hour training flight in which several methodologies will be standardized, including estimating distances to birds and data recording procedures. After each flight a question and answer session will be conducted in which crew members and leaders participate in examining how methodologies worked in differing scenarios. During the third day of training each crew member will receive safety training as required by the USFWS and the Department of Interior.

Weather restrictions. Weather restrictions and the relative safety of flight will be determined in the field and will depend upon weather conditions on any given day. Safety of the crew members and pilot will be the first priority in assessing if surveys should be conducted during inclement weather (high winds, precipitation). Crew leaders will question the pilot to determine if standard survey protocol (maintaining 62 – 100 m above ground and airspeeds averaging 145 kmph) may be followed and the plane safely flown. If the pilot and crew leader determines that surveys can not be conducted safely, surveys will be halted until weather conditions improve. Surveys will not be conducted during rain, snow, fog or other precipitation events that reduce observer visibility to less than one mile.

Ability to measure distance to birds. Because accuracy of estimated detection distances from the air is adversely affected by rough, uneven terrain (Thompson et al. 1998, Buckland et al.2001), we will not rely on visual estimation of horizontal distances or clinometers for this project in uneven terrain. Laser range finders apparently will not work for estimating distances of birds observed in flight in even or uneven terrain. For these reasons, we propose to fly the airplane to the approximate position where the bird was first observed (perched or flying) and obtain the location using a GPS unit (Anthony et al. 1999, Buckland et al.2001, Ayers and Anderson 1999). Bird silhouettes taped to the observers' windows representing the visual size of a golden eagle at different distances will also aid in estimation of distance to golden eagles that are flying. This method of distance measurement for flying eagles will be thoroughly tested during training.

Statistical Analysis

Perfect detection of individuals on the transect line is a primary assumption of standard DISTANCE procedures (Buckland et al. 2002), yet in many cases, detection of animals on or near the line is not certain and usually less than 100% (Brochers et al. 2002). Double-observer procedures for line transect sampling do not depend on this assumption (Borchers et al. 2002; McDonald et al. 1999; Manly et al. 1996). For illustration, see Figure 4 reproduced from Manly et al. (1996) where the probability of sighting an individual polar bear "on the transect line" by the front seat observer was estimated to be approximately 0.7 and 0.9 for groups of size two. Using the double-observer method, total population size is adjusted for missed animals by dividing the number of golden eagles sighted by a certain crew, at a certain distance, in a certain habitat type by the estimated probability of detection. Visibility biases will be corrected by modeling the detection probabilities using logistic regression. Statistical analysis using the double-observer method will follow Manly et al. (1996), and maximum likelihood estimation methods will be used to estimate the abundance of golden eagles within each Bird Conservation Region (BCR) and across the study area. Resampling (bootstrapping) will be used for design based estimates of precision and reduction of mathematical bias (Manly et al. 1996, Buckland et al. 2001). The double-observer method may be dropped in the future if we estimate that the probability of missing birds on the transect line, or birds in flight close to the aircraft, is small. Future surveys will not likely require the same amount of double-observer effort because baseline data of detection rates will already exist.

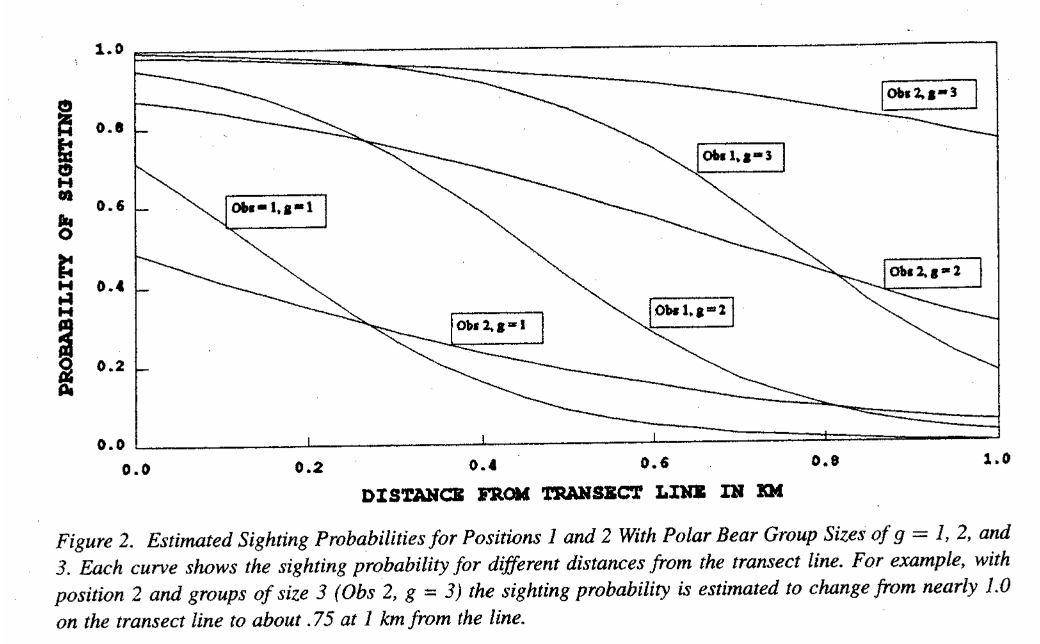

Figure 4. Reproduced from Manly et al. 1996.

Fuller et al. (2001) suggested that after data collection in a given year, one could possibly calculate a weighted average of the estimated abundance from aerial survey and the estimated abundance from the Breeding Bird Survey (BBS). This approach is plausible, and could reduce the necessary sample size (number and length of transects) for future aerial surveys. However, this approach can not be assessed until several years of aerial survey data are available for comparison of trend estimates from aerial survey with those from the Breeding Bird Surveys. We will compute estimates of population sizes in the three age classes and obtain BBS estimates of the same parameters, if available. All estimates will be reported along with the weighted averages of aerial transect estimates and BBS estimates. Professional judgment will be used to describe the confidence that should be placed in the various estimates and combinations of estimates. Professional judgment will also dictate whether sampling effort could be reduced or needs to be increased for the aerial surveys to meet the desired level of precision.

Following data collection and estimation of population sizes for each age class, a computer simulation will be designed to better estimate the sample size (number and length of transects) necessary for at least 80% power to detect an annual rate of population change greater than or equal to 3 percent per year over a 20-year period using a test of size alpha = 0.1 (or 90% confidence interval). Using data from the first year of the survey in the computer simulation will provide a more accurate sample size calculation, compared to the theoretical computations of Fuller et al. (2001). The results from this analysis will be included in the project final report, so the USFWS can evaluate the efficiency and effectiveness of future golden eagle surveys.

Quality Assurance (QA) and Quality Control (QC). QA/QC measures will be implemented in all stages of the study, including field data collection, data entry and analysis, and report preparation. Observers will be trained in methods used and observers will be tested during double sampling periods on their ability to identify and age golden eagles from a moving airplane. At the end of each survey day, observers will be responsible for inspecting data forms for completeness, accuracy and legibility. The study team leader will periodically review data forms to ensure completeness and legibility and correct any problems. Changes made to data forms will be initialed by the person making the change. Data will be entered in to electronic files by qualified technicians. The final data files will be compared to raw data forms and any errors corrected. Any irregular codes or unclear or ambiguous data will be discussed with the observer and team leader. After data have been entered and verified, the team leader will check approximately 10 % of the data forms against the final computer file. Any problems identified during the later stages of analysis will be traced back to the raw data forms, and appropriate changes will be made in all steps of the analysis.

A detailed quality assurance plan will be completed prior to the start of surveys. The plan will describe measures used to ensure the objectives of the contract are met.

6.0 Deliverables

Progress Reports

Assuming a start date for the project of July 1, 2003 the USFWS, Division of Migratory Bird Management will be provided with progress reports on the following dates: October 1 and, December 1, 2003 and March 1, 2004. These reports will describe overall project progress with respect to the proposed scope of services and project schedule. Any potential problems with meeting proposed timetables will be identified and solutions proposed in order to meet required deadlines. Each report will also include a summary of budgeted expenses to date.

Project Plan

Prior to the initiation of surveys, we will provide, Michael McFarlane, Office of Aircraft Services (OAS), with a project plan describing the dates, times and locations where surveys will take place. The OAS will also be provided with other information pertinent to surveys, including number of passengers, heights and speeds at which the plane will be flown, and procedures for locating and identifying golden eagles.

Final Report

Assuming a project start date of July 1, 2003, we will issue a final report to the USFWS, Division of Migratory Bird Management by June 1, 2004. The final report will include the following information to allow the USFWS to better manage golden eagle populations throughout the western U.S.:

- A total population estimate and an estimate of the number of immature, subadult and adult golden eagles within the western U.S. and within each Bird Conservation Region
- Ratios of immature: subadult: adult population segments and interpretations based on comparisons with existing literature of how the ratios may relate to the current status of the population
- An evaluation of the efficacy of the proposed survey methods after one year of data collection, including suggestions for improving future survey results

- Computer simulations of survey data to determine if sample sizes are sufficient to meet the desired precision requirements
- A detailed long term monitoring plan, including proposed methods for detecting population trends, proposal time framework for future monitoring, and funding required for future surveys.

The results of the initial year of study will be used as a basis for determining plans for future monitoring. Important questions that will be answered during the initial year of study include:

1. Were sample sizes (number and length of transects) more than enough or too low to detect 3 % changes in population per year over an estimated 20 years at the required precision levels?
2. Can the study area be stratified in order to more efficiently sample golden eagle populations?
3. Are detection rates on the transect line high enough to justify eliminating or reduce double observer efforts?

Design and Analytical Methods for Detecting Population Trends. The primary objective is to estimate adult, subadult, and juvenile golden eagle numbers and total population size in the study area using aerial transect procedures such that, if replicated annually, the survey would have at least 80% power to detect an annual rate of population change greater than or equal to 3 percent per year over a 20-year period using a test of size alpha = 0.1 (or 90% confidence interval).

It is possible to detect a trend in population size over time with a smaller sample size than would be necessary to detect rate of change in absolute abundance of a population over time (with the same precision and accuracy) if some or all of the same transects are flown during future surveys. Tradeoffs between design of future surveys for estimation of trend verses estimation of change in absolute abundance will be discussed in the final report. These issues have been studied in research conducted by Trent L. McDonald, Bryan F.J. Manly, and Ryan Nielson, WEST, Inc., Cheyenne, Wyoming. Trent McDonald has a paper in press entitled "Review of Environmental Monitoring Methods: Survey Designs" to be published in Environmental Monitoring and Assessment 2002, pages 1-16. Under certain assumptions, Urquhart and Kincaid (1999) come to the same conclusion "The panel designs [with some or all fixed survey units] turn out to be far superior to independent surveys for detecting trend and have other desirable features."

Two considerations for design of future monitoring surveys will be investigated by computer simulations based on precision of the first years data: number of transects to be surveyed in a given year and the frequency at which the population surveys should be conducted (e.g., annual versus biannual).

Required Funding. We anticipate the costs of future surveys to be substantially lower for the following reasons:

- Computer simulation using data from first year may indicate that sample size (number and lengths of transect) could be reduced for future surveys and still be able to obtain desired level of precision.

- Analysis of data may indicate that stratification could be done to increase precision and may be more efficient
- Double-observer effort may be eliminated or reduced due to a finding of 100% detection on the transect line. Alternatively, a "visibility bias correction model" based on the first years data might be used in later surveys if the same aircraft are used and the observers are required to have the same experience and training.
- Much of the preliminary work will be completed the first year and not needed in future surveys, so the required effort will be reduced (e.g. creating maps, drawing up transect lines, training, data management and analysis).
- After a sufficient number of years of aerial surveys are conducted it will be possible to investigate combining trend estimates from BBS with trend estimates from aerial surveys. If trend estimates between the two methods show sufficient similarities, aerial survey effort may again be reduced in future years and more effort put into obtaining and using BBS data

Although it is difficult to predict what elements of the surveys may be reduced in the future, we anticipate the costs of future surveys may be reduced from $40,000 - $100,000.

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7.0 Project Schedule

July 1, 2003 – Begin project preparation (Determining final transect locations, preparing data sheets etc)

August 1, 2003 – Provide Office of Aircraft Services with project plan detailing flight locations, altitude and speed requirements and other pertinent information

August 15, 2003 – Provide the USFWS with Quality Assurance Plan

Mid August, 2003 – Conduct Safety, Golden Eagle Aging and Methodology Training

August 18, 2003 – Begin Golden Eagle Surveys

September 15, 2003 – Finish Golden Eagle Surveys

October, 2003 – Enter and organize data, begin data analysis, begin work on progress report

December 1, 2003 – Provide USFWS with Progress Report

January – February, 2004 Finish data analysis and Final Report

March 1, 2004 – Provide USFWS with Progress Report

April – May, 2004 – Review and Finalize Report

June 1, 2004 – Provide the USFWS with Final Report

9.0 Why Hire the WEST Team?

The team assembled by WEST, Inc. provides the U.S. Fish and Wildlife Service with an unmatched combination of statistical and survey design expertise, knowledge of golden eagle biology, and the necessary experience and personnel to carry out a logistically complex survey over most of the western U.S. Biologists and statisticians within the WEST team are well published in peer reviewed journals and have the capability and knowledge to produce a survey design and population estimate that will meet the most rigorous scientific standards, and will allow the U.S. Fish and Wildlife Service to best manage golden eagle populations over the long term.

Appendix A. Standard Operation Procedures and data to be recorded.

1. Distances of golden eagles from the aircraft.

The location of a sighting is defined to be the latitude-longitude of the aircraft on a particular transect line at the point of intersection of a perpendicular projection from the golden eagle or center of a group of eagles.

Flying golden eagles. All birds sighted on the wing will be recorded and the distance to the bird will be estimated and recorded. Once a bird is sighted on the wing the position (GPS) and altitude of the aircraft will be recorded. Due to the difficult in estimating distances to flying birds, two methods will be used to estimate distances. Using silhouettes of birds pasted on windows, observers will estimate the initial distance to the flying bird. Silhouettes will be of differing sizes based on relative size of bird in relation to distance from the aircraft. After estimating the initial distance, the aircraft will then pull off the transect line and fly to the bird's approximate location when the bird was observed. The altitude and position of the observed location will then be recorded, and the distance from the bird/bird group sighted to the flight-line along a perpendicular projection will calculated using the position of the aircraft and the position of the bird(s), at the time of the observation.

Perched golden eagles. All birds sighted on the ground or perched will be recorded and distance to the bird or bird group will be estimated and recorded. Horizontal distance will also be measured from the bird/bird group sighted to the inside edge of the observation strip along a perpendicular projection for even terrain. Once a golden eagle is observed, the GPS location and altitude of the aircraft will be recorded. The aircraft will then pull off the flight-line in order to accurately age classify the bird and obtain a GPS reading of the bird's location.

2. Aging of eagles

Golden eagles will be aged based on molt patterns at the base of the tail and primaries and secondaries (Bloom and Clark 2002, Kochert et al. 2002). Juvenile golden eagles (0 – 1 yrs) and subadult (1 – 4.5 yrs) have overall darker plumage, white primaries and secondaries which form a white patch on the wing, and white band at the base of the tail. Both of these characteristics are visible from above or below the bird. Because the amount of white at the base of the tail and the wings decreases with the age of the bird, golden eagles may generally be classified as juvenile (dark feathers with very white patches on wings and at the base of the tail), subadult (less contrast between white patches and darker feathers as the white feathers are replaced during subsequent molts) and adults (virtually no white in wings or tail). Final aging criteria will be based on the training and workshop planned for mid August and taught by Bill Clark. Depending on the orientation of the bird to the aircraft, aging characteristics may not be visible by observers on transects. In order to accurately age birds observed from transects, the airplane will be flown toward the bird until an accurate determination of age can be made.

3. Double-observer method

Two observers will always occupy the back seat of the aircraft. When the double-observer (3rd observer) is available for a flight, he/she will be positioned in the front of the aircraft (front-right seat). The observers on the right side of the aircraft (front-right and back-right positions) will be used as the "double-observers" and will allow the statistician to correct for visibility bias (golden eagles missed) in the analysis. The double-observer method requires that the front-right and back-right seat observers have the same field of view, and a curtain or wall dividing the two observers be in place to ensure observations of birds are independent between the two observers. Corrections obtained for the right-rear observer from the double-count method will also be used to correct observations of the left-rear observer. When only two observers are available for a flight both observers will be positioned in the back of the aircraft and Service personnel will be invited to accompany the crew. Corrections obtained from the double-observer method for similar habitat conditions and aircraft will be used to correct observations of the left and right-rear observers in all flights.

4. Reporting by pilot and back left observers.

For each golden eagle sighting, these two observers will record or alert the data recorder that an eagle or group of eagles has been sighted. The observer will state the position of the eagle as either left or right of the transect line, and provide a geographic reference point near the bird(s) location, so that the pilot can maneuver the aircraft directly above the bird for accurate age classification and distance measurements. For example, if during a survey an observer sees an adult golden eagle and two juveniles on the left of the transect line approximately ½ mile away from the transect, perched on a snag, the pilot or back left observer will announce "left, ½ mile, perched on snag, 3 total eagles, 1 adult, 2 juveniles." When only two observers are present, the observers should announce the sightings just prior to when the bird group is positioned perpendicular to the aircraft. When a third observer is present during correction trials, observers will wait until the plane has completely passed the observation before calling out locations to the pilot. During double sampling, observers will secretly record the position of the aircraft when the plane is perpendicular to the observation.

The pilot's primary responsibility during the surveys is safety and staying on the designated flight path (transect line). We will stress to the pilots that a constant, consistent, airspeed and height above the ground is crucial to the success of the surveys. However, the pilot will be encouraged to make observations and alert the crew if an eagle was missed by the back-left observer.

5. Reporting by recorder and back right observer.

For as many of the surveys as possible (at least 1/3 of the surveys), a double-count sampling approach will be used on the right side of the aircraft. In this approach, the front and back seat observers (recorder and back right) will not announce the eagle observations when they are observed. Instead the observer will quietly record the sighting information on his/her field data sheets. Once the bird(s) is passed and out of sight of the back seat observer and no other eagles are in sight on that side, the observer(s) will announce the sighting. An accurate distance measurement and age classification will then be obtained by flying off the transect line and over the observed bird. A determination will be made based on whether both observers saw the eagle.

6. Automatic data recording.

Location of the aircraft, time, and date are obtained and recorded automatically by the GPS/computer at fixed intervals (we suggest every 10 seconds). This permits plotting of the actual flight path versus the theoretic lines.

7. Altitude and air speed.

A radar altimeter is used to help the pilot keep the aircraft at the intended height above the ground. To measure the discrepancy between the actual and intended height flown, the height is also recorded on the computer by viewing the instrument at fixed time intervals (we suggest 5 to 10 minute intervals). Airspeed can also be recorded in a similar fashion.

8. Transect, observer, and weather documentation.

At the beginning and end of each survey flight when the aircraft is on the ground or in transit to the survey area, the recorder is responsible for entering documentation. Documentation includes, but is not limited to, the crew names, their positions within the aircraft, weather conditions, flight-line numbers to be flown, and the direction the flight lines are flown.

The recorder is responsible for categorizing weather and sighting conditions throughout the survey flight. Weather conditions include percent cloud cover (10ths), ceiling height, precipitation, approximate wind direction and velocity, and sunshine. Sighting conditions are categorized into good, fair, and poor based upon degree of overcast, precipitation, and flat light conditions. These observations are recorded on the transect log and coded to the corresponding time given by the computer.

9. Observer data recording.

Each backseat observer is responsible for recording all of the sightings on the paper observer data sheets. This provides quality control of the data entry by the data recorder. These sightings will be cross- checked each evening with the computer data files. Each observer will indicate when another observer, the pilot, or the recorder announces a sighting to ensure proper verification of sightings.

12. Pilot and recorder responsibilities.

The pilot is responsible for flying transect lines and maintaining desired survey altitude and airspeed. The recorder is responsible for recording all sightings from all participants on the computer and acting as the double-observer in the front-right seat of the aircraft. When the double-observer is not available for a flight, the back-left observer will act as the data recorder. To avoid confusion the pilot will not call out or record sightings independently except those that are missed by the primary observers.

Appendix B. Resumes of Key Personnel

Appendix C. Representation and Certifications

Appendix D. References for Principal Investigators

Mr. Scott Schleibe, U.S. Fish and Wildlife Service, Marine Mammals, 1011 E. Tudor Road, Anchorage, Alaska 99503. Telephone: 907786-3812

Dr. Robert Skinner, U.S. Fish and Wildlife Service, Charles M. Russell NWR, P.O. Box 110, Airport Road, Lewistown, Montana 59457. Telephone: (406) 538-8706

Dr. Grainger Hunt, The Peregrine Fund, 5668 West Flying Hawk Lane, Boise, Idaho 83709. Telephone 208-362-3716

Mr. Steve Steinhour, SeaWest WindPower, Inc., 1455 Frazee Road, Ninth Floor, San Diego, California 92108-4310. Telephone: 619-293-3340